



WINS NG 2.0

Current Status and Network Assembly

Santa Fe, NM

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Sensoria Corporation

Internetworking the Physical World

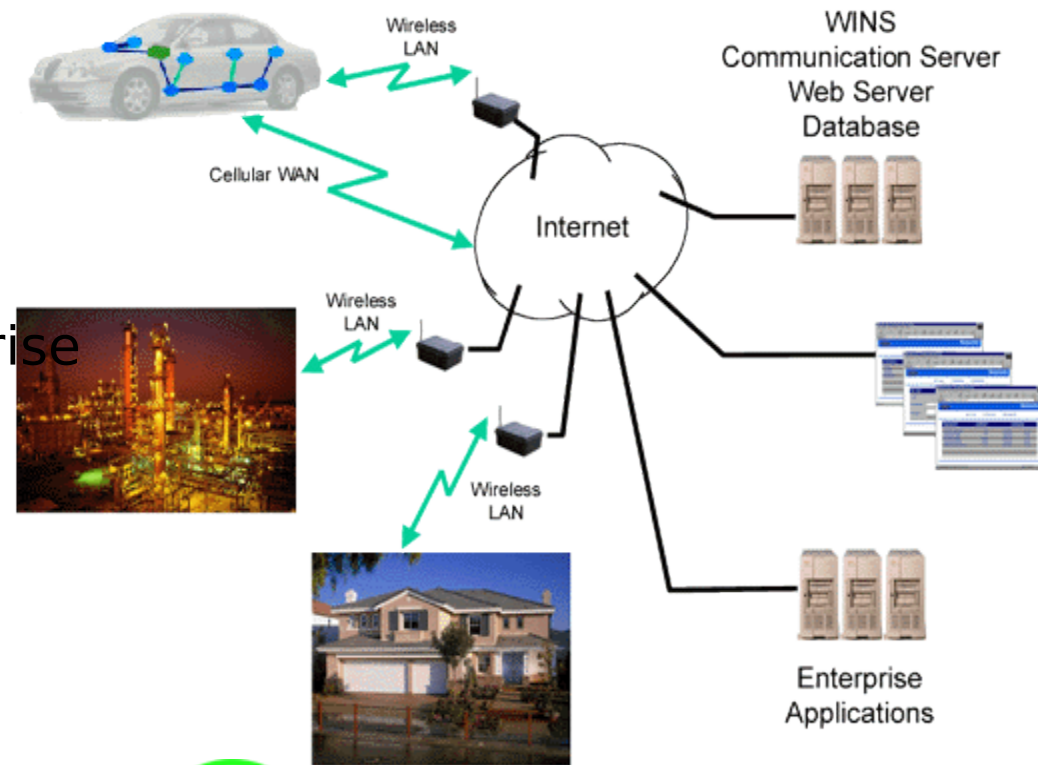




Sensoria Corporation Introduction



- Sensoria Corporation is an innovator of networking embedded computing systems
- Products for:
 - Defense
 - Automotive
 - Industrial
 - Health Care Logistics
- Integrated Edge-to-Enterprise Platforms
 - SensIT Development
 - SHM Platform
 - PicoWINS Tags
 - Automotive Telematics Gateway





WINS Node Status



- Ninety WINS NG 2.0 development nodes have been delivered to the SensIT community prior to SITEX02.
 - Development platform including, high speed sampling, RF support, GPS, Linux 2.4 Kernel, ...
 - Embedded sensing node with expanded capability to support development
- Additionally Two WINS Imager v.2 have been provided.
 - Authorized in October, delivered later that month
 - Provide WINS NG 2.0 development environment integrated with an imaging module, currently visible CCD
 - In process of evaluating use of uncooled thermal IR subsystems
- Latest v1.3 WINS NG 2.0 and Imager software updates provided December 2001.
 - Updates Linux Kernel to 2.4.16
 - Updates development tools, to track latest open source updates
 - Including 3.0.2 compiler
 - Refines RF and sensing APIs
 - Updates RF robustness
 - Updates capability of GPS synchronization with sampling





WINS NG 2.0 at SITEX02



- Seventy-five node WINS NG 2.0 nodes and two Imagers were deployed for SITEX02
 - Heavy utilization over 3 weeks provided user feedback on:
 - With complete software distributions were loaded at SITEX02, kernel panics were observed in the 2.4.8 kernel distributed with the first WINS NG 2.0 build
 - This was resolved with the open source community updates to the Linux 2.4.12 kernel operating on the SH4
 - Tested with a random input test (the crashme utility), operated on the nodes for extended periods without failures on the new Kernel provided at SITEX02
 - GPS module failures
 - ~10 nodes returned due to GPS module hardware failure
 - Currently testing operation and correcting available nodes
 - Requested updates to node synchronization
 - Coordinated with Pete Boettcher to allow PPS access on the SH4 to support NTP
 - Request for an http server to transfer images from the imager
 - Porting apache web server is in process
 - Feedback is appreciated, in order to duplicate and identify observed issues

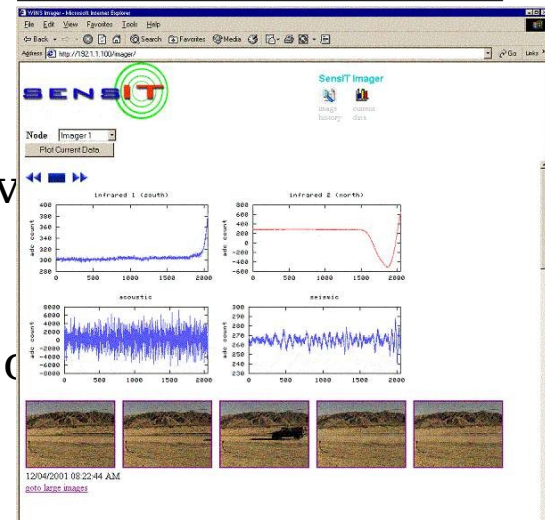
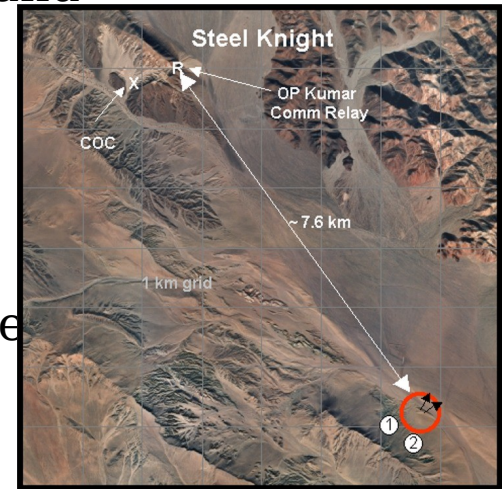




Steel Knight Imager Deployment



- To provide a SensIT demo at Steel Knight, Sensoria and BBN installed
 - 2 Imagers
 - a long range 802.11b link
 - a database server
 - a web based GUI
- WINS Imager v 2.0 operated continuously over a week
 - Linux 2.4.12 kernel, with sampling API running continuously
 - Each Imager equipped with 2 PIR, seismic and acoustic
 - Imager's triggered locally with the PIR sensors
 - Only problem over two weeks when database server was shut down accidentally (by W.J.K.)
- Provided imaging within seconds of vehicle passage
 - Sequences of pictures provided to capture, large and multiple targets





Steel Knight Sample Images



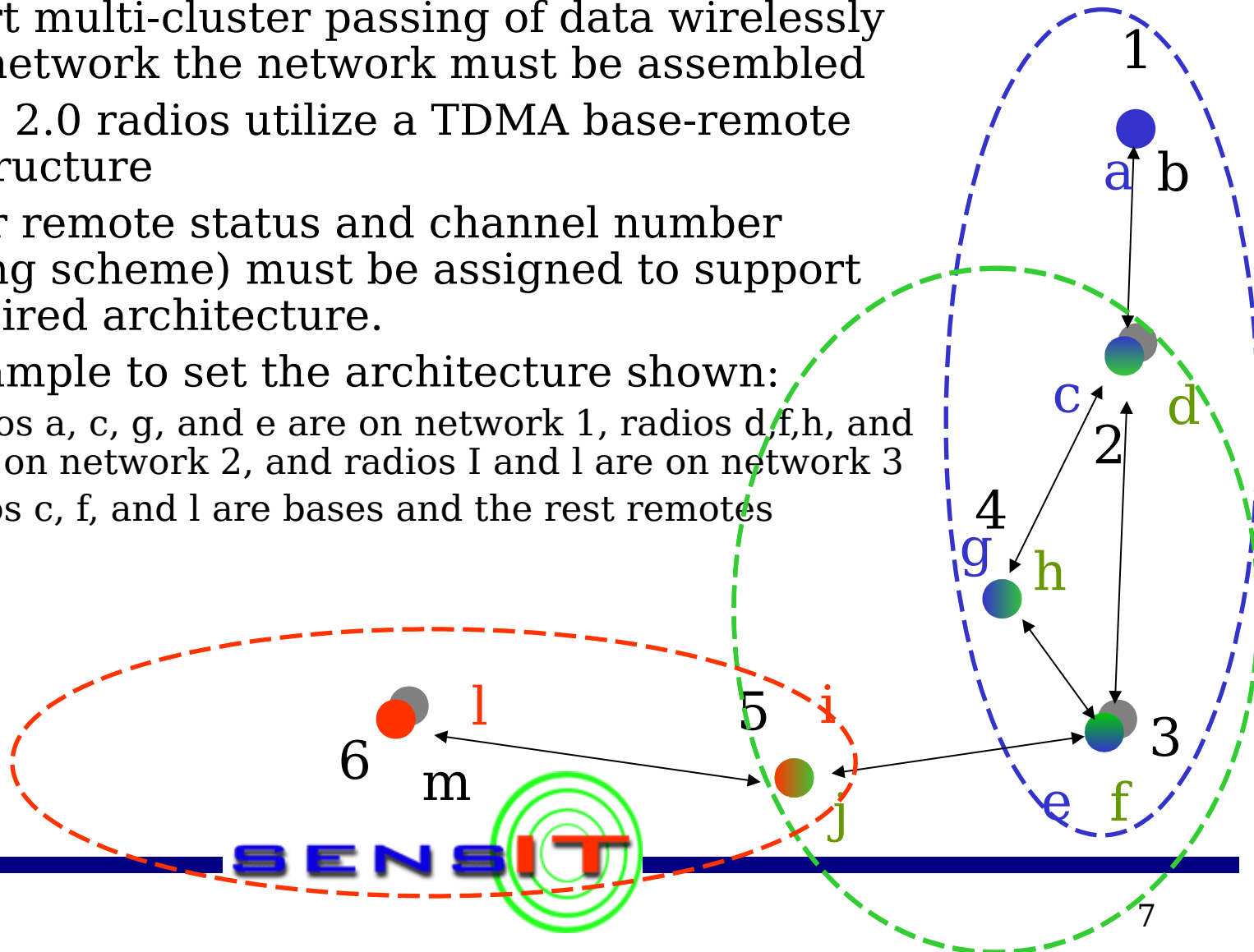
SENSIT



WINS NG 2.0 Network Assembly



- To support multi-cluster passing of data wirelessly over the network the network must be assembled
- WINS NG 2.0 radios utilize a TDMA base-remote cluster structure
 - Base or remote status and channel number (hopping scheme) must be assigned to support the desired architecture.
 - For example to set the architecture shown:
 - Radios a, c, g, and e are on network 1, radios d, f, h, and j are on network 2, and radios i and l are on network 3
 - Radios c, f, and l are bases and the rest remotes





Radio Configuration



- Function calls to configure each radio are available in the rfmodemd driver.
 - Ioctl() calls to configure the network, base/remote status, and Tx power
- Scripts can run on each node at start up to build their own deterministic networks.
 - Defined network for comparison with self assembled.
 - Reconfigurable for testing multiple scenarios.
- Suitable to a demo or experiment with a fixed node layout.
 - Autonomous network assembly a development option for each of the PIs, with Sensoria developing supporting technology to be delivered in the third year of the program
 - Additional need for self-assembled networks to place and forget





Autonomous Self-Assembly Considerations



- Each base supports up to 16 remotes, however 7 or less remotes per base are recommended.
 - RF channel TDMA sliced between base and remotes, limiting packet sizes as more remotes are added
- RF communication is environmentally dependent
 - Expected ground-to-ground distance is $>30\text{m}$ at the MCAGCC desert environment.
 - Base to remote distance, per leg of the star or cluster.
 - Increases to $>70\text{m}$ for nodes at a height of 1.5m .
- Base operation requires more power than remotes
 - To maintain synchronization without transmitting data bases use $\sim 420\text{mW}$, compared to $\sim 90\text{mW}$ for remotes (at 100mW transmit power).
 - Additional cost to send data is $\sim 20\text{mJ/kbit}$ at the base and $\sim 50\text{mJ/kbit}$ at the remote.





Autonomous Self-Assembly Considerations



- Nodes decide base/remote and network state with local information
 - WINS NG 2.0 baseline is to use two default networks (known hopping patterns)
 - Each radio listens as a remote on one network
 - Becomes a base if does not hear another base after random interval
 - Updates to network structure (base and network assignment) based on:
 - Node locations within a cluster
 - Number of remotes per base
 - Remaining power
 - Link QoS, or signal strength
- Operation limited by robustness and adaptability
 - Respond to node destruction/ power failure
 - Incorporate new nodes with a minimum of communication
- Focus on a distributed decision, on each node to support multi-cluster multi-hop architecture





Conclusions



- 90 WINS NG 2.0 nodes supplied to SensIT
 - Operation demonstrated by multiple organizations both at SITEX02 and for this meeting
 - Continued upgrades and support of RF API, Sampling API, GPS, and Development Environment
- 2 Imagers v 2.0 supplied to SensIT
 - Demonstrated operation at the end of SITEX02, and at Steel Knight, also present here
- Next steps include:
 - Self assembly of the WINS NG 2.0 RF network
 - WINS NG 2.0 and Imager refinements

